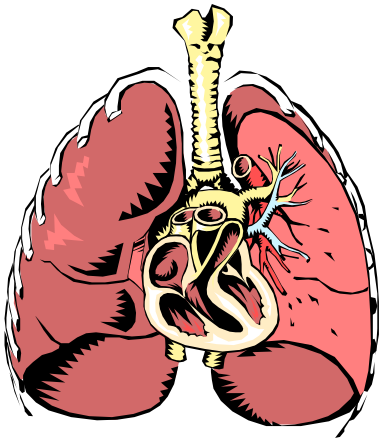
Bio& 242:
Unit 2 / Lecture 2



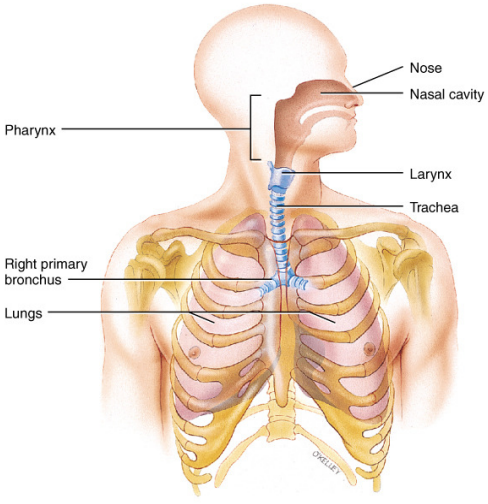
Processes of the Respiratory System

- **Pulmonary ventilation**

  mechanical flow of air into and out of the lungs
- **External Respiration**

  exchange of gases between the pulmonary air spaces and the blood
- **Internal Respiration**

  exchange of gases between blood and tissues



(a) Anterior view showing organs of respiration

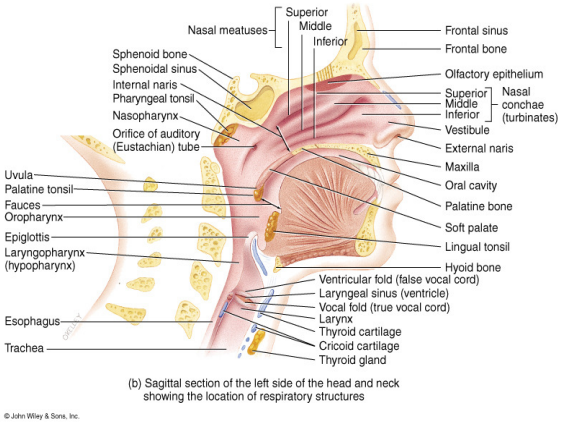
Structural Portions of the Respiratory System

- Upper Respiratory System

  1. warming, moistening and filtering incoming air;

  2. receiving olfactory stimuli

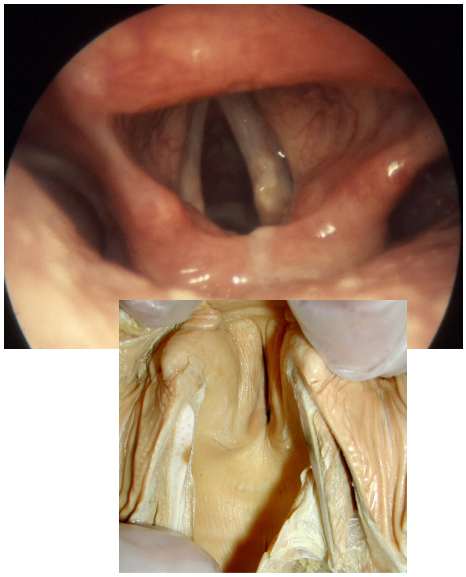
  3. serving as large, hollow resonating chambers to modify speech sounds



(b) Sagittal section of the left side of the head and neck showing the location of respiratory structures

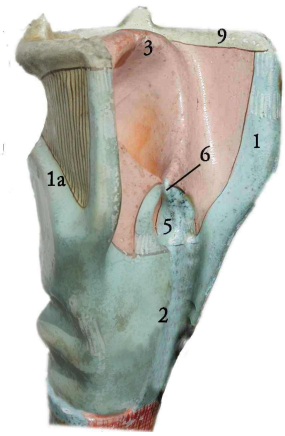
Structural Portions of the Respiratory System

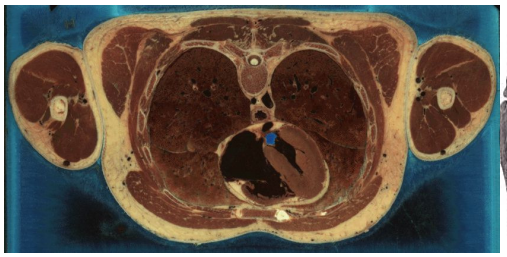
- LARYNX
- *connects the pharynx with the trachea.*
- *Contains: the thyroid cartilage*
- *epiglottis which prevents food from entering the larynx*
- *cricoid cartilage which connects the larynx and trachea,*
- *paired arytenoid, corniculate and cuneiform cartilages.*
- *True Vocal folds*
- *Opening between the true vocal folds called the glottis.*



LARYNX

1. thyroid cartilage
2. cricoid cartilage
3. epiglottis
5. arytenoid cartilages
6. corniculate cartilages
9. hyoid bone





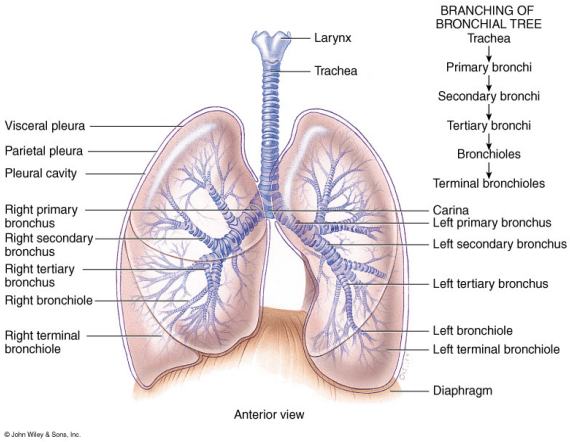
- *The right lung has three lobes separated by two fissures (horizontal and oblique).*
- *The left lung has two lobes separated by one fissure (oblique) and has a depression called the cardiac notch.*
-

Structural Portions of the Respiratory System

- **Lower Respiratory System:**

  Contains a set of conducting ducts that carry air to the exchange surfaces.

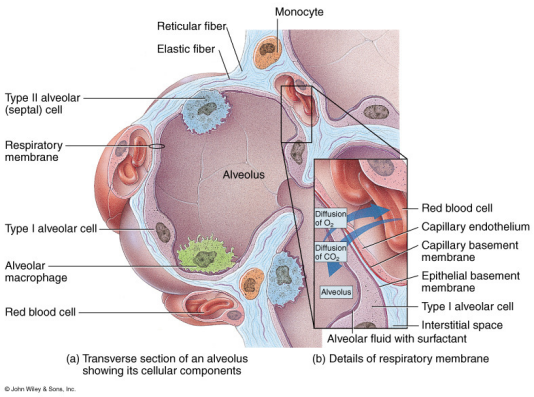
You need to know their order.

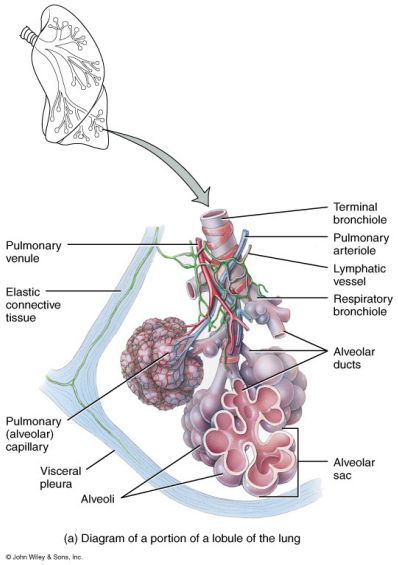


Structural Portions of the Respiratory System

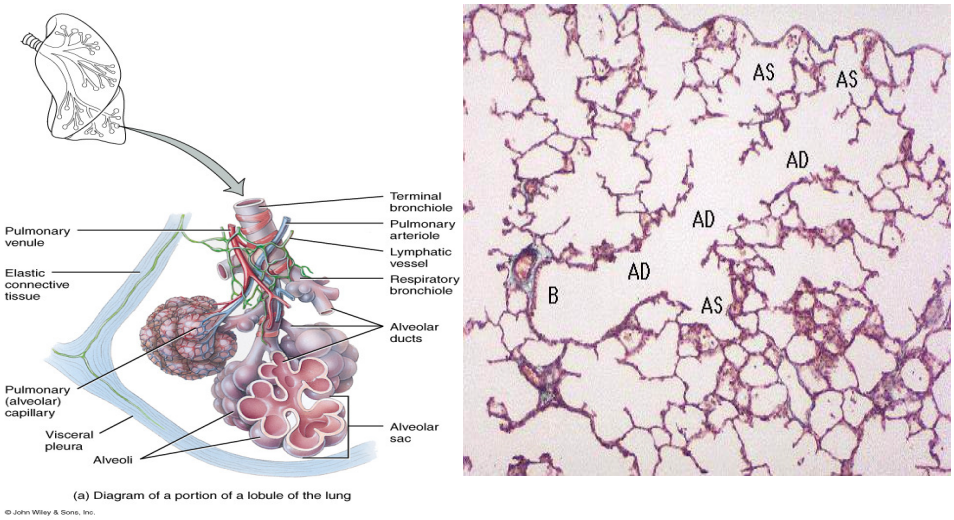
- **Lower Respiratory System**

  Respiratory Portion





Microscopic Anatomy of a Lobule



Pulmonary Ventilation
Inspiration

- **Muscles of Inspiration**

  Primary Muscle:

  Diaphragm – only muscle active during normal breathing or eupnea

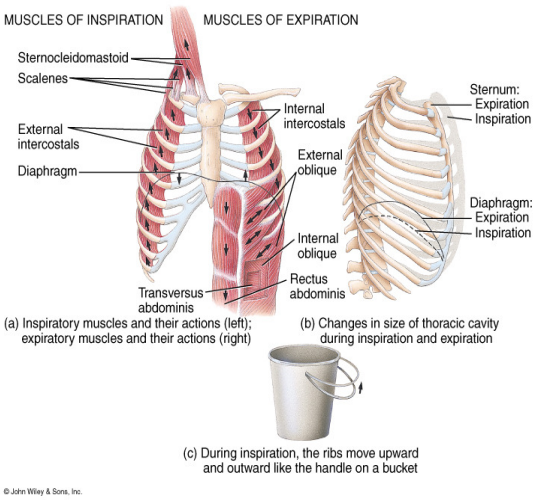
  Secondary Muscles

  Active during deep breathing

  Sternocleidomastoid

  Scalenes

  External Intercostals



Pulmonary Ventilation
Expiration

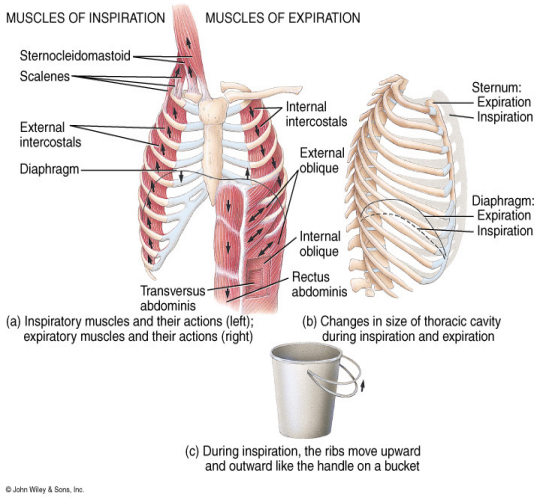
- **Muscles of Expiration**

  Primary Muscle:

  Diaphragm is inactive

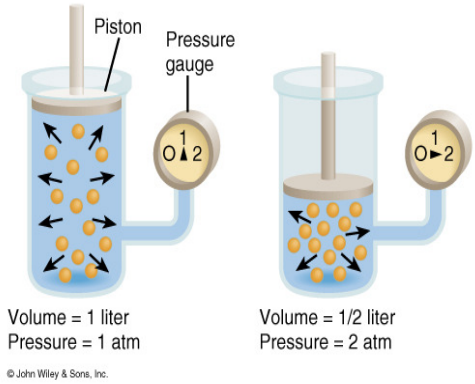
  Secondary Muscles active during deep breathing:

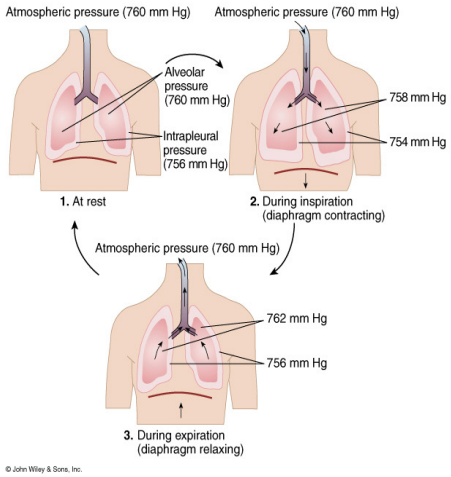
  Internal Intercostals
  External Oblique
  Internal Oblique
  Transversus Abdominis
  Rectus Abdominis



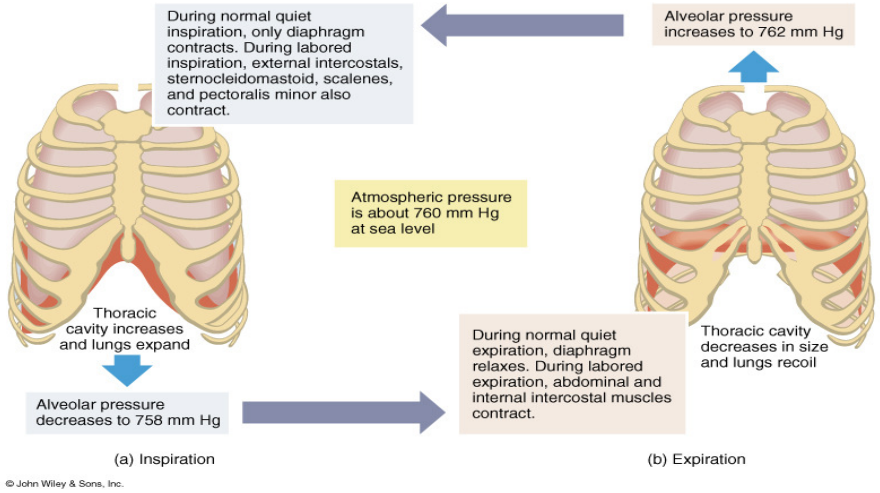
Pressure Changes in Pulmonary Ventilation and Boyle's Law

Pressure is inversely related to Volume





Summary of Inspiratory and Expiratory Events



Factors Affecting Pulmonary Ventilation

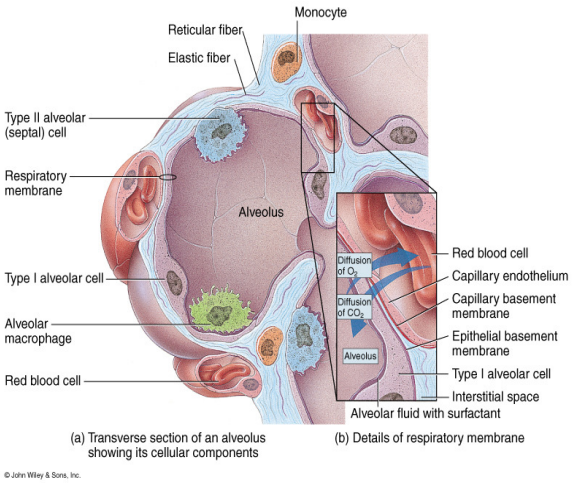
- **Surface Tension**

  Surfactant decreases surface tension thus preventing alveolar collapse

- **Compliance**

  High compliance means the lungs and thoracic wall expand easily

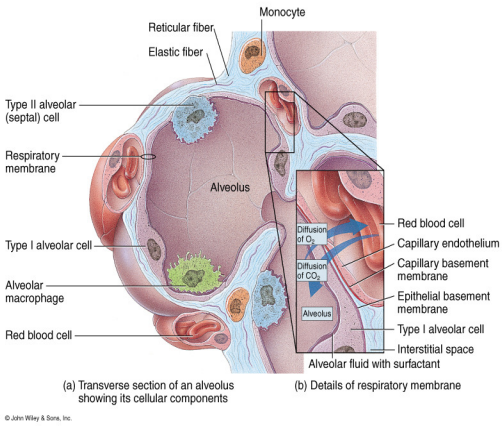
  Low compliance means that they resist expansion



Factors Affecting Pulmonary Ventilation

- **Decreased Compliance**

1. **Tuberculosis – scarring of the lungs**
2. **Pulmonary edema - Retention of fluid in lung tissue**
3. **Respiratory Distress Syndrome – Lack of surfactant in premature infants**
4. **Paralysis of respiratory muscles**
5. **Emphysema – destruction of elastic fibers in alveolar walls**




healthy lung tissue


lung with emphysema

Factors Affecting Pulmonary Ventilation

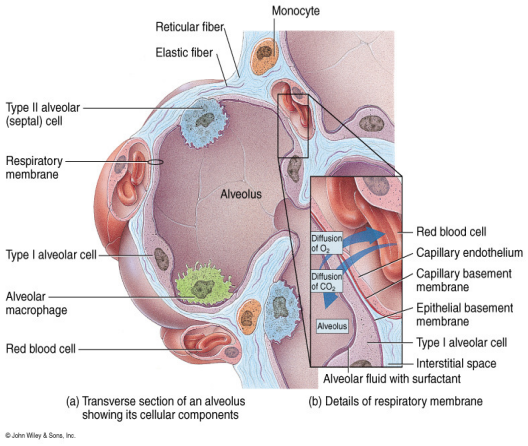
- **Airway Resistance**

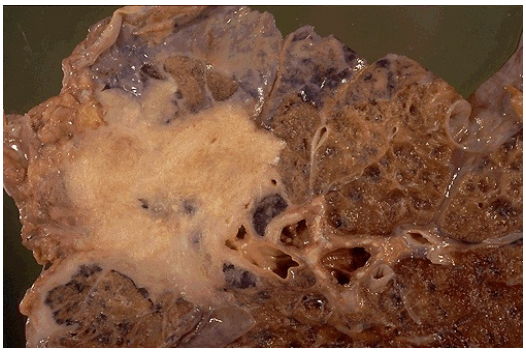
  Any condition or obstruction of airways that increases resistance.

  Chronic Obstructive Pulmonary Disease (COPD) asthma

  Emphysema

  Chronic Bronchitis

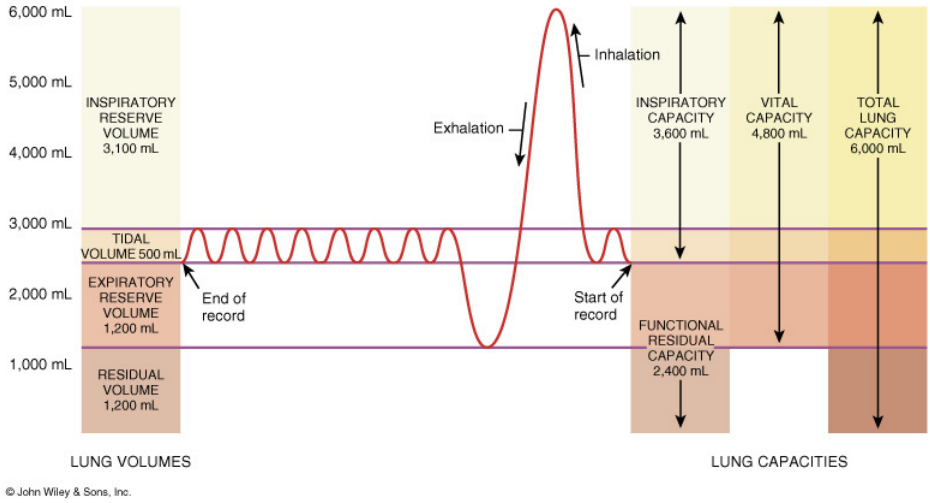




- **Smoking during pregnancy increases risk**
  Children whose mothers smoked during pregnancy were 2½ times more likely to have ADHD than children who weren't parentally exposed to tobacco.
- Children with blood lead levels of more than 2 micrograms per deciliter were four times more likely to have ADHD than children with levels below 0.8 microgram per deciliter. The government's "acceptable" blood lead level is 10 micrograms per deciliter, and an estimated 310,000 U.S. children ages 1 to 5 have levels exceeding that.
- Based on study estimates, more than 5 million 4-to-15-year-olds nationwide have levels higher than 2 micrograms per deciliter..

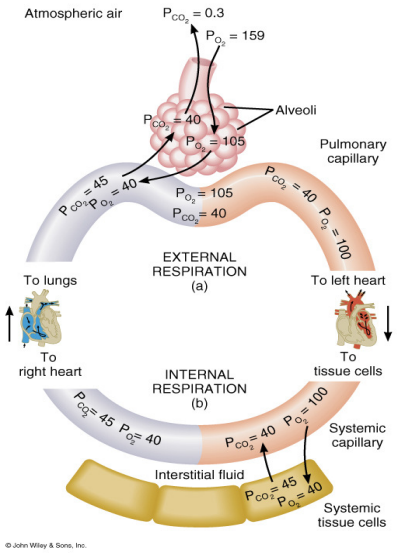
From: Exposures to Environmental toxicants and Attention deficit Hyperactivity. By Joe Braum et.al.
Environmental Heath Perspectives, Vol 114, Number 12, p 1904

Lung Volumes and Capacities



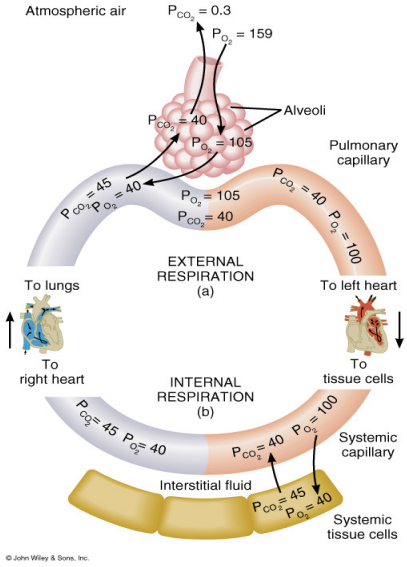
Factors Affecting External Respiration

1. **Partial Pressure of gases**
2. **Alveolar surface area**
3. **Diffusion rate and distance**
4. **Solubility of each gas and molecular weight of the gas**
5. **Hemoglobin affinity**



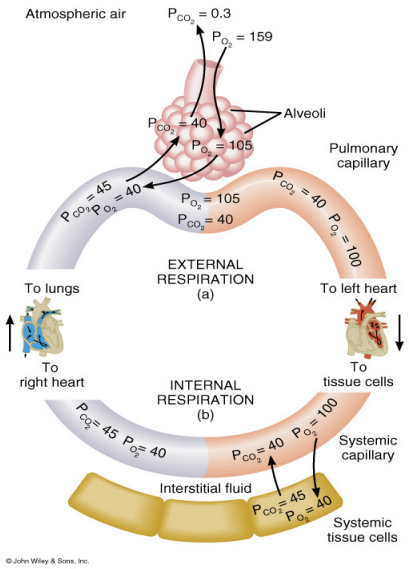
Factors Affecting External Respiration

- **Dalton's Law –**
  Atmospheric pressure is the sum total of all partial pressures of all gases in the atmosphere
- **N2 78% 597.4 mm Hg**
- **02 21% 158.8 mm Hg**
- **CO2 >1% .3 mm Hg**



Factors Affecting External Respiration

- **Dalton's Law and High Altitude Sickness**
- **Sea Level: pO2 160 mm Hg**
- **10,000ft.: pO2 110 mm Hg**
- **20,000ft.: pO2 73 mm Hg**
- **50,000ft.: pO2 18 mm Hg**



Factors Affecting External Respiration

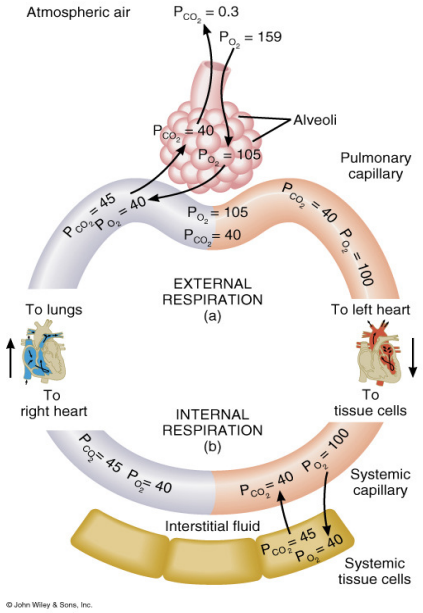
- **Henry's Law**

  Quantity of a gas that will dissolve in solution is proportional to the partial pressure and the solubility coefficient (SC) of the gas.

  SC CO2 = .57

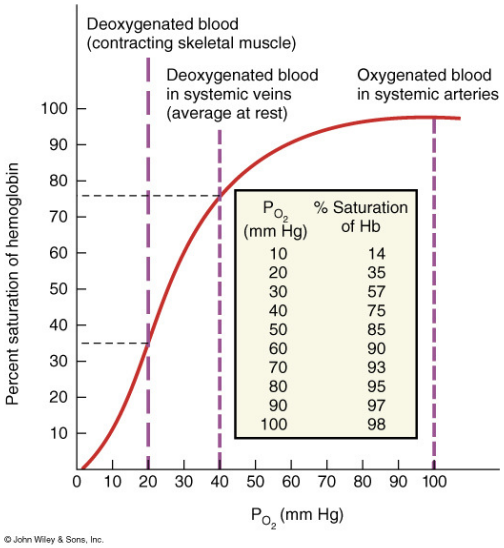
  SC O2 = .024

  SC N2 = .012



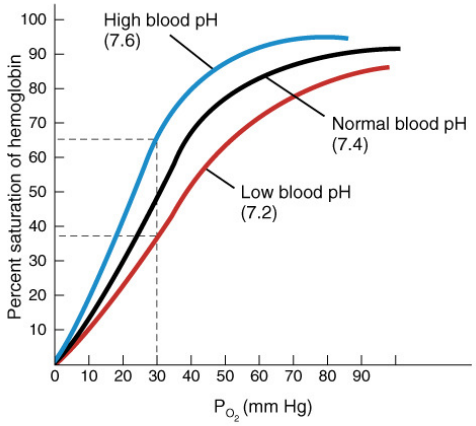
Factors that affect Oxygen Transportation by Hemoglobin

1. **pH (blood acidity)**
2. **Partial pressure of CO2**
3. **Blood Temperature**
4. **2,3-bisphosphoglycerate (BPG)**



The Effect of Blood pH on the Affinity of Hemoglobin for O2

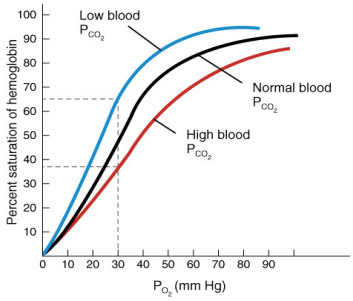
- **Increased pH of blood (more basic), the greater the affinity**
- **Decreased pH of blood (more acidic), the lower the affinity**



(a) Effect of pH on affinity of hemoglobin for oxygen

The Effect of pCO2 on the Affinity of Hemoglobin for O2

- Low pCO2, the higher the affinity
- High pCO2, the lower the affinity
- H2O + CO2
- Bohr Effect

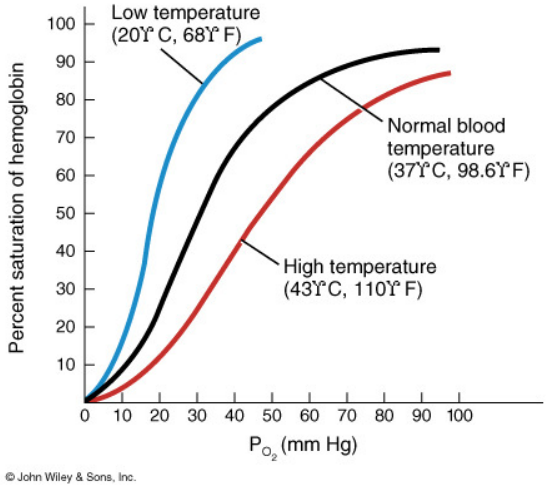


(b) Effect of P_{CO_2} on affinity of hemoglobin for oxygen

H20 + CO2 ⟹ Carbonic Acid (H2CO3) ⟹ H+ + HCO3

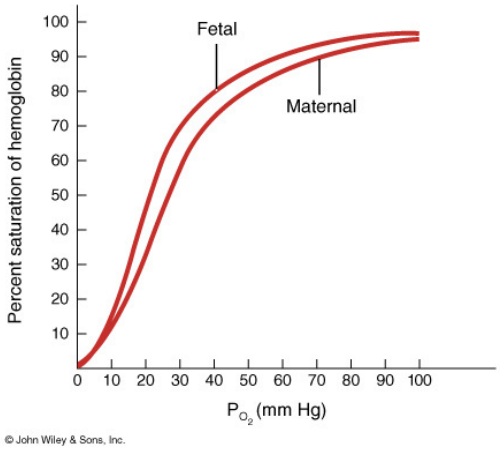
The Effect of Blood Temperature on the Affinity of Hemoglobin for O2

- **Lower the temperature, the greater the affinity**
- **Higher the temperature, the lower the affinity**



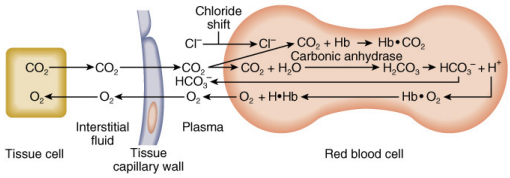
The Difference between Fetal and Maternal Hemoglobin for O2 Affinity

- **For efficient gas exchange between a fetus and its mother, fetal hemoglobin has a higher affinity for O2 than maternal hemoglobin.**

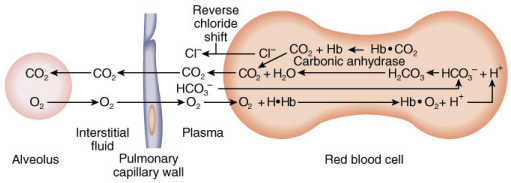


Summary of Gas Exchange during both External and Internal Respiration

- **O2 is carried on hemoglobin forming Oxyhemoglobin.**
- **7% of CO2 is carried as dissolved CO2**
- **25% of CO2 is carried as carbaminohemoglobin**
- **70% of CO2 is carried as bicarbonate ions**



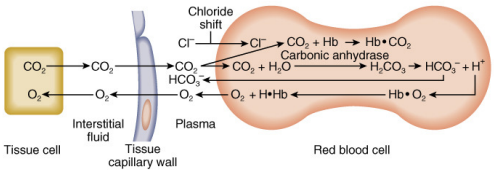
(a) Exchange of O_2 and CO_2 in the tissues (internal respiration)



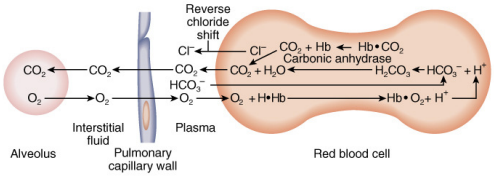
(b) Exchange of O_2 and CO_2 in the lungs (external respiration)

Summary of Gas Exchange during both External and Internal Respiration

- **Haldane effect: The lower the oxyhemoglobin, the higher the CO2-carrying capacity of the blood.**
- **Deoxyhemoglobin binds more readily with CO2**
- **Deoxyhemoglobin also acts as a better buffer absorbing more H+, causing more bicarbonate to form.**



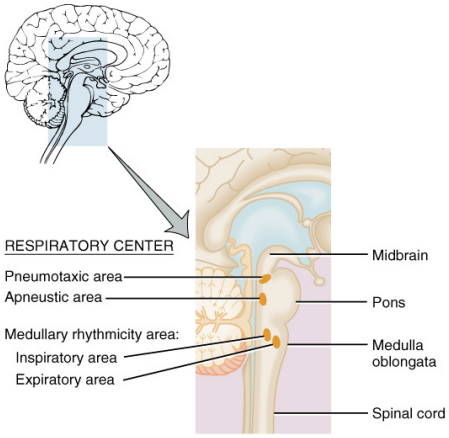
(a) Exchange of O_2 and CO_2 in the tissues (internal respiration)



(b) Exchange of O_2 and CO_2 in the lungs (external respiration)

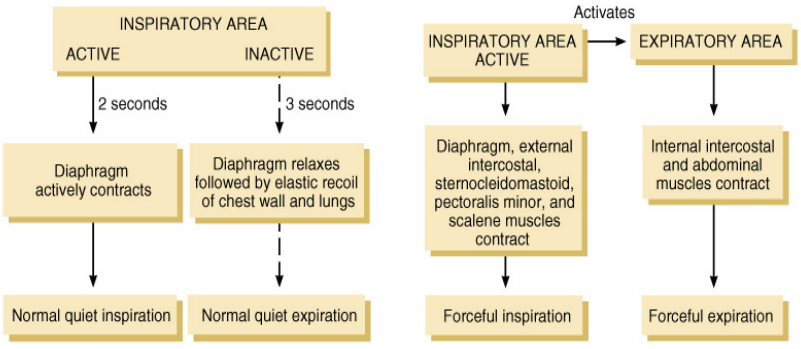
Nervous Control of Pulmonary Ventilation & the Respiratory Centers

- **MRA: Controls the basic rhythm of ventilation**
- **PA: transmits inhibitory impulses to the inspiratory area**
- **AA: Transmits stimulatory impulses to the inspiratory area**



Sagittal section of brain stem

Proposed mechanism of ventilation control



(a) During normal quiet breathing

(b) During labored breathing

Chemical Regulation of Respiration

- **Aortic Body: Cluster of chemoreceptors located in the wall of the aortic arch that respond to H+**
- **Carotid Bodies: Cluster of chemoreceptors located in the walls of the L & R Carotid arteries that respond to H+**
- **Central chemoreceptors: located in the Medulla Oblongata also respond to H+**

Clinical Terms

- **Hypercapnia: Arterial Blood PCO2 above 40mmHg**
- **Hypocapnia: Arterial Blood PCO2 below 40mmHg**
- **Hyperventilation: Rapid/deep breathing**
- **Hypoventilation: Slow/shallow breathing**
- **Hypoxia: O2 deficiency at the tissues**
- **Hypoxic hypoxia: Due to high altitude, airway obstruction or fluid**
- **Anemic hypoxia: Deficiency of hemoglobin**
- **Ischemic hypoxia: Decreased blood flow**
- **Histotoxic hypoxia: Caused by toxic agent like cyanide which prevents tissues from using O2**